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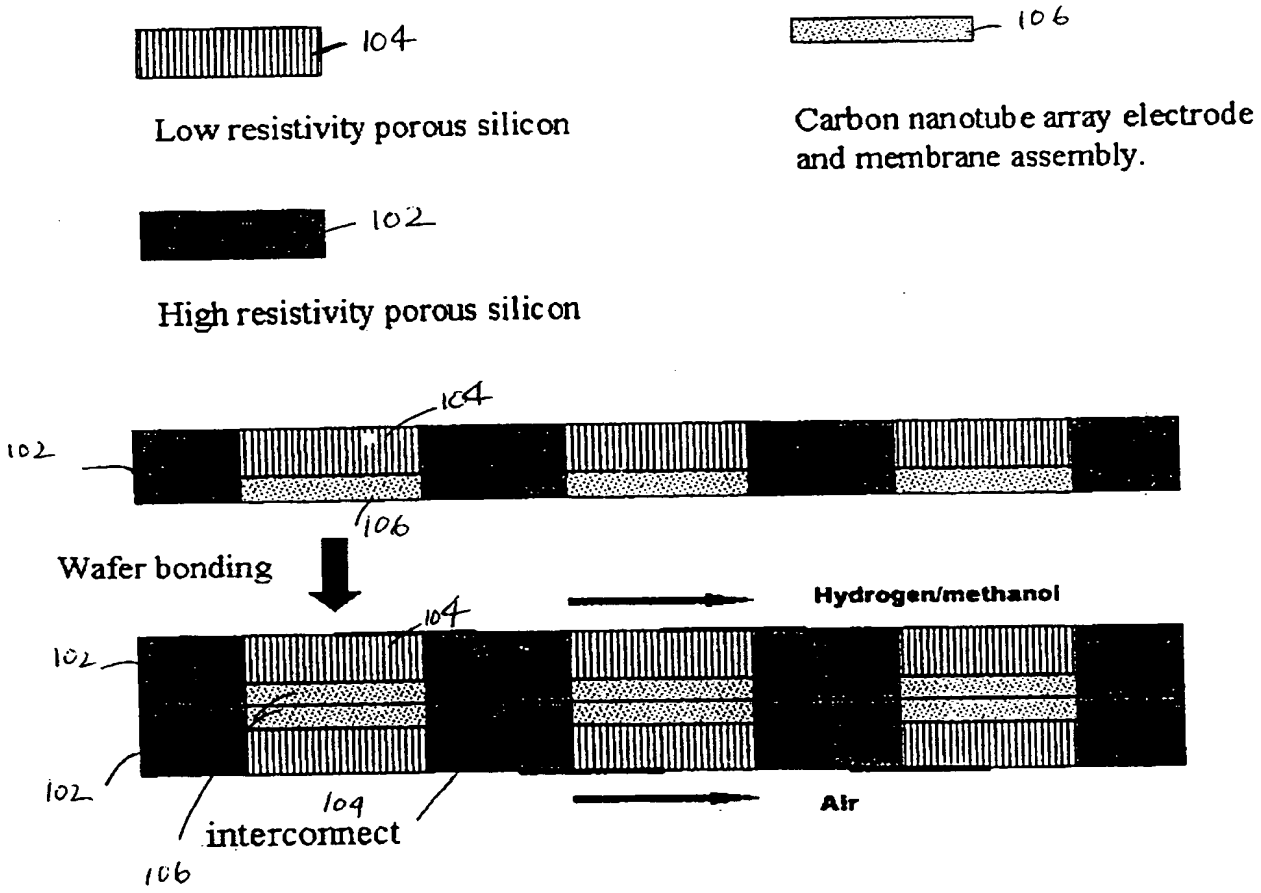
104
Low resistivity porous silicon
106
Carbon nanotube array electrode and membrane assembly.
102
High resistivity porous silicon
104
102
106
Wafer bonding
Hydrogen/methanol
104
102
102
109
interconnect
106
Air

FIG. 1

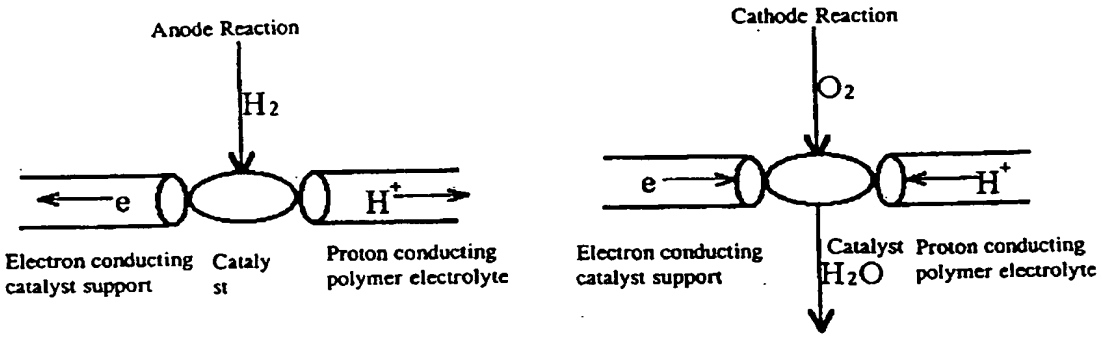
Anode Reaction
H_2
e
H^+
Electron conducting catalyst support
Cataly st
Proton conducting polymer electrolyte
Cathode Reaction
O_2
e
H^+
Electron conducting catalyst support
Catalyst H_2O
Proton conducting polymer electrolyte

FIG. 2

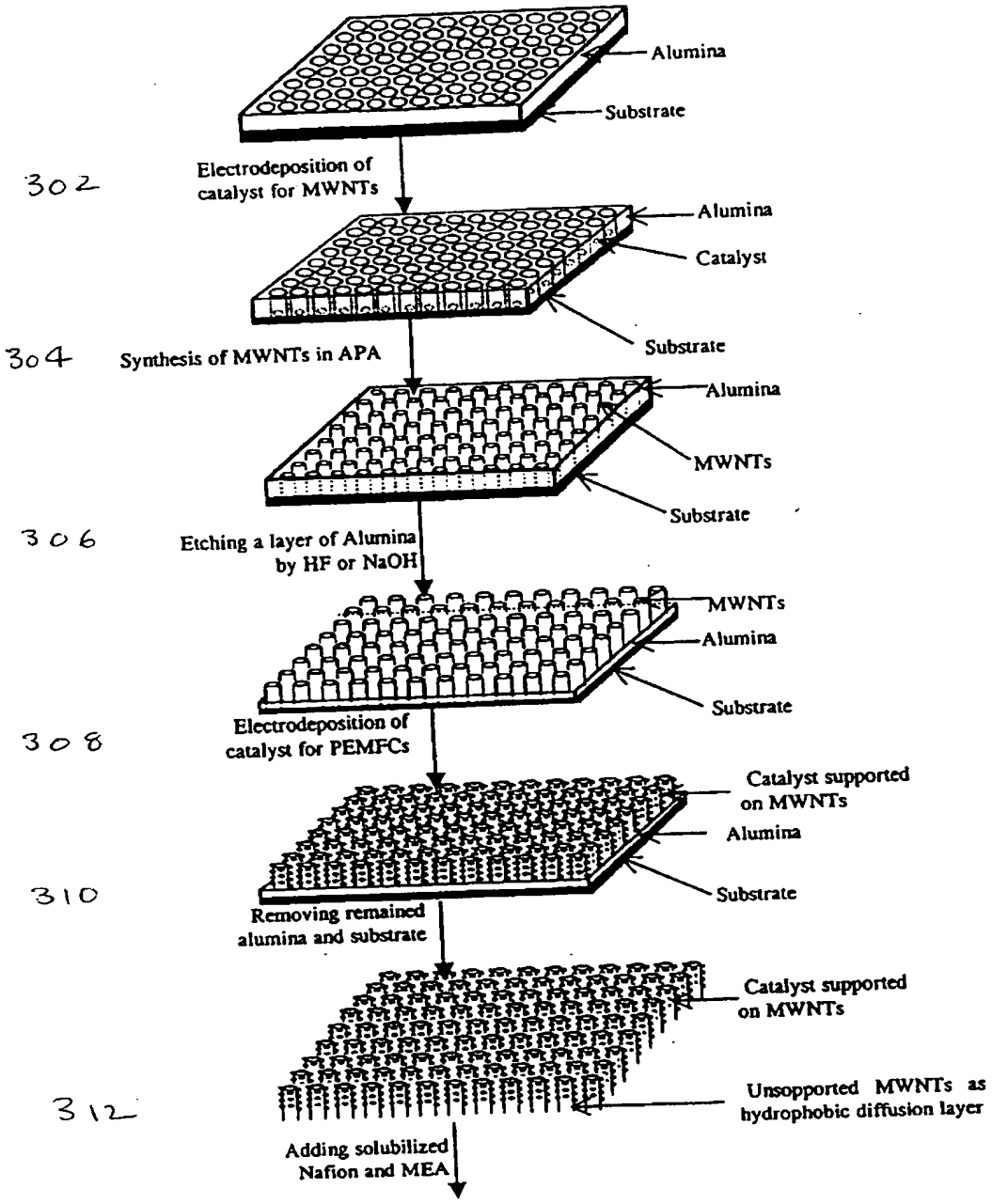
Alumina
Substrate
302
Electrodeposition of catalyst for MWNTs
Alumina
Catalyst
Substrate
304
Synthesis of MWNTs in APA
Alumina
MWNTs
Substrate
306
Etching a layer of Alumina by HF or NaOH
MWNTs
Alumina
Substrate
308
Electrodeposition of catalyst for PEMFCs
Catalyst supported on MWNTs
Alumina
Substrate
310
Removing remained alumina and substrate
Catalyst supported on MWNTs
Unsopported MWNTs as hydrophobic diffusion layer
312
Adding solubilized Nafion and MEA

FIG. 3

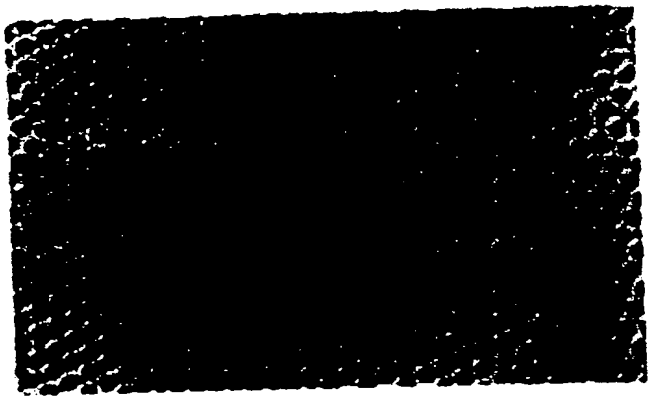

FIG. 4

FIG. 5

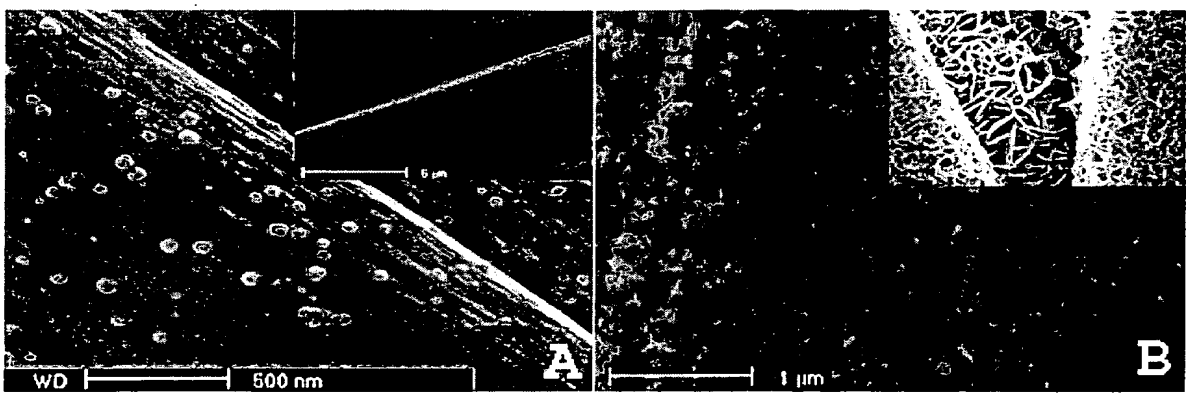

Fig. 6: SEM micrographs of carbon paper after electrodeposition of Co: A) with 0.26 mg/cm^2 Co (inset is bare carbon paper) and B) with 4 mg/cm^2 Co (inset is 20 mg/cm^2 Co).

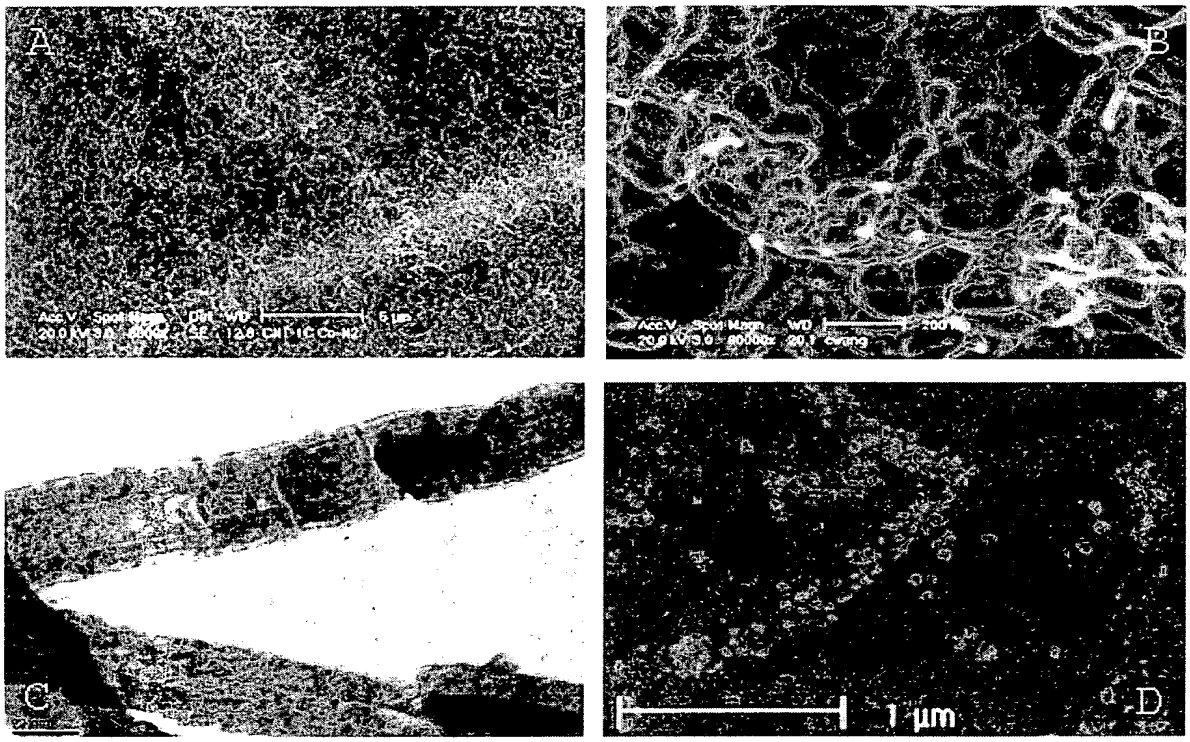

Fig. 7: SEM and TEM micrographs of MWNTs grown by 0.26 mg/cm^3 Co loading on carbon paper; A) SEM with low magnification showing high coverage of MWNTs on carbon paper; B) SEM with higher magnification showing the diameter of the MWNTs and presence of Co catalyst particles; C) TEM of MWNTs, D) SEM of Pt particles electrodeposited on MWNTs.

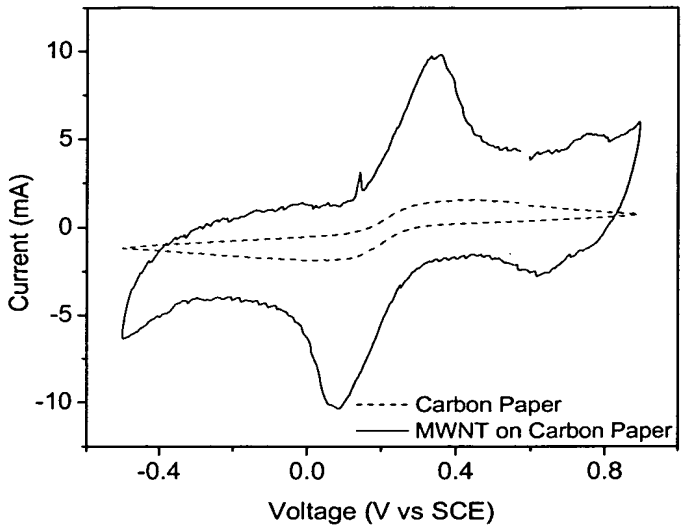

Fig. 8: Cyclic Voltammetry in a $K_3Fe(CN)_6$ solution (5 mM $K_3Fe(CN)_6$ + 0.5 M K_2SO_4) of: 1) 3.46 cm^2 of carbon paper alone; 2) MWNTs grown by 0.26 mg/cm^2 Co loading covering the same 3.46 cm^2 carbon paper. Scan rate: 50 mV/s.

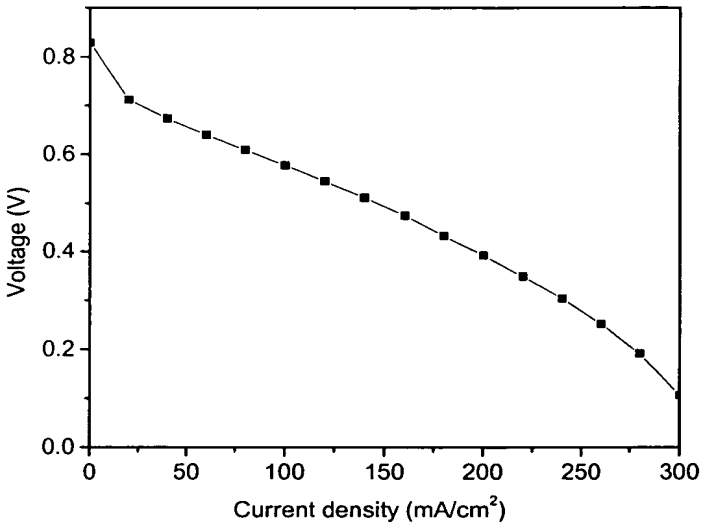

Fig. 9: Polarization curve of a MEA prepared by electrodeposition of Pt on MWNTs grown by 0.26 mg/cm^2 Co loading. Pt loading on both electrodes: 0.2 mg/cm^2. Membrane: Nafion 115. Operating conditions: cell temperature, 70°C; humidifier temperature, 80°C; pressure, 2 atm.